# THE WINTER-GREEN HERBACEOUS FLOWERING PLANTS OF OHIO[1]

JANICE C. BEATLEY

*Department of Botany and Plant Pathology, The Ohio State University, Columbus 10*

Nearly everyone is familiar in some way with plants which are green in winter in the Deciduous Forest region. The evergreen conifers, especially the pines, spruces, firs and cedars, planted extensively for landscape purposes, are probably the most widely recognized. In fact, the terms evergreen and conifer are commonly used by the layman as synonyms. Winter wheat, and the bluegrass and dandelions of lawns are likewise familiar species which add greenness to landscapes in a season when the leaves of most plants have withered and died. Overwintering leaves of candytuft, foxglove, sweet william, chrysanthemum, and others are well-known to gardeners and nurserymen. Botanists have long been aware of the winter-green leaves of such shrubs as *Rhododendron*, *Kalmia*, and others of the Heath Family, as well as the frequency of winter-greenness among ferns, and the conspicuous greenness of mosses, as a group, in the winter aspect of almost any forest.

During the months of November through February, however, when snow cover is absent, there is a large population of green herbaceous plants in field and forest which appear little or none the worse for the presumed rigors of the season. Far from being devoid of herbaceous plants in the winter, the ground is dotted with green nearly everywhere. This population consists of many different kinds of plants, and the species, genera, or families to which they belong often cannot be ascertained by the usual vegetative characters customarily used in their identification. These are the plants with which this paper is concerned.

Earl (1907) noted that a number of species in Ohio are winter-green in addition to conifers and woody dicots. In her compilation 16 genera and 27 species of herbaceous angiosperms are cited. She classed *Glechoma hederacea* and some species of *Lamium* among the most hardy of herbaceous perennials, the genera *Senecio*, *Taraxacum*, and *Achillea* among the more hardy of the winter-green rosette plants, and such species as *Poa pratensis* and *Nepeta cataria* among those which partly withstand freezing. Of this list, one species (*Sempervivum tectorum*) is strictly cultivated, three are not known to occur in Ohio from The Ohio State University herbarium records (*Moneses uniflora*, *Pyrola asarifolia* and its variety *purpurea*), and one is considered to be very doubtfully winter-green (*Malva rotundifolia*).

Griggs (1914) classified the evergreen plants in the Sugar Grove region of Ohio in three groups: (1) "Typical shade-loving evergreens with leaves appearing late in the season", consisting of *Goodyera pubescens*, *Pyrola elliptica*, and *Epigaea repens;* (2) "shade-loving herbs with hibernating leaves replaced in spring by new ones", represented by *Hepatica acutiloba*, *H. americana*, *Carex plantaginea*, *Tiarella cordifolia*, and *Maianthemum canadense;* and (3) "evergreen herbs with leaves or shoots ascending sufficiently from the ground partially to surmount a blanket of fallen leaves", in which *Mitchella repens* and *Gaultheria procumbens* are the flowering species cited.

There apparently has been no attempt made, in North America at least, to list comprehensively the winter-green species of any geographical area, to describe these species in the winter condition, or to devise keys by which they may be

[1]Publication 564, Department of Botany and Plant Pathology, The Ohio State University.

identified in winter. Lidforss (1907) enumerated more than 130 winter-green central and northern European vascular species growing in the Botanical Gardens at Lund, Sweden, which were used in his chiefly physiological studies of winter-green plants. More recently Nilsson (1949) has observed degrees of winter hardiness exhibited by over 4,200 ornamental herbaceous species growing in Sweden.

The standard manuals of Fernald (1950) and Gleason (1952) make only occasional reference to species as being winter-green. A rather large number of introduced weed species are described as "winter annuals" in the weed manuals of Muenscher (1935) and Georgia (1923), covering the ranges of *Gray's Manual* and *Britton and Brown's Illustrated Flora*, and in various publications encompassing the weed floras of more limited areas. Mention of perennial species which are winter-green, in treatises of any kind dealing with the taxonomy, ecology, or physiology of flowering plants, is rare, and descriptions of winter annuals or winter-green perennials in the winter condition are essentially non-existent.

## SOURCES OF DATA

During the winters of 1945–48, more than 1,000 herbaceous winter-green plants were selectively collected in the field and transplanted in clay pots. Thereafter some were placed in cold frames in The Ohio State University Botanical Garden, duplicate specimens were placed in the greenhouse, and triplicate specimens, when collected, were retained for the herbarium. As these plants flowered and fruited, they were identified and the determinations checked with specimens in The Ohio State University herbarium. Although a number of problems were encountered in maintaining this extremely diverse population in such a manner that anthesis might occur in all, determinations were ultimately made of all but a half-dozen or so plants. After the first year, collections were made between mid-December and the last of February since it became evident the first winter that for many of our native species there is a cold period requirement, necessary for the breaking of winter dormancy, which is not fulfilled in this region until sometime in December.

Collections were made by habitat, and such habitats as seemed most likely to contain chiefly native flora were the principal collecting areas. The most extensive collections were made in the Hocking Hills of Fairfield and Hocking Counties, Ohio, because of the region's great diversity of habitats and richness of flora. The winter herbaceous flora of the Oak and Mixed Mesophytic communities of this region is considered to be representative of these communities throughout most of the Allegheny Plateau of eastern and southern Ohio. Collections were also made in Beech-Sugar Maple forests in central Ohio, and in swamp forests, prairies, bogs, old field communities, and on pioneer sites in both central and southern Ohio. A number of stands of all of the principal forest types of central and southern Ohio were visited over the three-year period, and it is believed that most, if not all, of the winter-greens which are at all common in forest communities of this part of the State were collected. The flora of the upland forests was relatively more thoroughly studied than the more diverse flora of some of the swamp forest types. Likewise forest species were more intensively collected than species of pioneer communities or other sites on which various stages of succession were occurring.

## THE WINTER-GREEN FLORA

In the list which follows are included all flowering plant species (excepting shrubs) which are known from the present field study to be green throughout the winter in central and southern Ohio. Such species as *Saponaria officinalis*, in which many of the leaves often remain green until midwinter but have obviously been so severely injured that recovery will not ensue, have not been included.

Species referred to as "winter annuals" by Muenscher (1935), Georgia (1923), or Runnels and Schaffner (1931), which were not collected during this investigation but which are known to occur in Ohio from records of The Ohio State University herbarium, have also been included; these are marked with an asterisk—almost all are Eurasian weed species, many of which are rare or have restricted distributions in the State at the present time. Except for three species, the Panicums have been included on the authority of Hitchcock and Chase (1950), who characterize the group to which these Ohio species belong as having "basal leaves usually distinctly different from those of the culm, forming a winter rosette." A few other species are included on the authority of other authors, and are so designated by citation of their publications. Synonymy and phylogenetic order are essentially those of Fernald (1950).

It is not presumed that the list includes all of the herbaceous angiosperms which regularly have green, living leaves throughout the winter in Ohio. Grasses, sedges, and rushes were collected only occasionally, and these families without question, on the basis of field observations, are only partially represented. Several members of the Labiatae remain unidentified because of failure of anthesis under greenhouse or cold frame conditions, and it seems probable that a number of additional species in this family will be demonstrated to be winter-green. Representatives of the Cruciferae in the present list are largely the "winter annuals" of the weed manuals, and the native biennial and perennial winter-green mustards are doubtless not well represented in this compilation. The present list, consisting of 287 species, represents about 16 percent of Ohio's herbaceous flowering species. It is anticipated that the percentage will be no less than 20 when the list is more nearly complete.

**Gramineae**

*Bromus kalmii* Gray
*B. secalinus* L.*
*B. japonicus* Thunb.*
*B. mollis* L.*
*B. sterilis* L.*
*B. tectorum* L.*
*Poa pratensis* L.
*Hordeum jubatum* L.*
*Elymus virginicus* L.
*Hystrix patula* Moench
*Deschampsia caespitosa* (L.) Beauv.
*Danthonia spicata* (L.) Beauv.
*Agrostis perennans* (Walt.) Tuckerm.
*Cinna arundinacea* L.
*Panicum linearifolium* Scribn.
*P. bicknellii* Nash
*P. microcarpon* Muhl.
*P. boreale* Nash
*P. dichotomum* L.
*P. yadkinense* Ashe
*P. meridionale* Ashe
*P. lanuginosum* Ell.
*P. villosissimum* Nash
*P. columbianum* Scribn.
*P. sphaerocarpon* Ell.
*P. polyanthes* Schultes
*P. malacophyllum* Nash
*P. oligosanthes* Schultes
*P. leibergii* (Vasey) Scribn.
*P. xanthophysum* Gray
*P. commutatum* Schultes
*P. clandestinum* L.
*P. latifolium* L.
*P. boscii* Poir.
*Andropogon virginicus* L.

**Cyperaceae**

*Carex plantaginea* Lam.
*C. platyphylla* Carey
*C. gracilescens* Steud.

**Juncaceae**

*Juncus effusus* L.
*Luzula acuminata* Raf.
*L. campestris* (L.) DC.

**Liliaceae**

*Chamaelirium luteum* (L.) Gray
*Allium vineale* L.

**Iridaceae**

*Iris virginica* L.

**Orchidaceae**

*Goodyera pubescens* (Willd.) R. Br.
*Aplectrum hyemale* (Muhl.) Torr.

**Polygonaceae**

*Rumex crispus* L.
*R. obtusifolius* L.
*R. acetosella* L.

**Portulacaceae**

*Claytonia virginica* L.

**Caryophyllaceae**
*Scleranthus annuus* L.*
*Spergula arvensis* L.*
*Arenaria serpyllifolia* L.
*Stellaria media* (L.) Cyrillo
*S. longifolia* Muhl.
*Cerastium vulgatum* L.
*C. arvense* L.*
*C. nutans* Raf.
*C. viscosum* L.
*Agrostemma githago* L.
*Lychnis alba* Mill.
*Silene antirrhina* L.
*S. dichotoma* Ehrh.*
*S. noctiflora* L.*
*S. caroliniana* Walt. (Braun, 1928)
*S. virginica* L.
*S. rotundifolia* Nutt.
*Dianthus armeria* L.

**Nymphaceae**
*Nuphar advena* (Ait.) Ait. f.

**Ranunculaceae**
*Ranunculus sceleratus* L.*
*R. abortivus* L.
*R. recurvatus* Poir.
*R. septentrionalis* Poir.
*Hepatica americana* (DC.) Ker
*H. acutiloba* DC.
*Anemone virginiana* L.
*Isopyrum biternatum* (Raf.) T. & G.
*Coptis groenlandica* (Oeder) Fern. (Fernald, 1950)
*Aquilegia canadensis* L.

**Papaveraceae**
*Chelidonium majus* L.
*Argemone mexicana* L.*
*Corydalis flavula* (Raf.) DC.

**Brassicaceae**
*Draba cuneifolia* Nutt.*
*D. reptans* (Lam.) Fern.*
*D. verna* L.
*Berteroa incana* (L.) DC.*
*Thlaspi arvense* L.*
*T. perfoliatum* L.*
*Lepidium campestre* (L.) R. Br.
*L. virginicum* L.
*L. densiflorum* Schrad.*
*Coronopus didymus* (L.) Sm.
*Capsella bursa-pastoris* (L.) Medic.
*Camelina sativa* (L.) Crantz*
*C. microcarpa* Andrz.*
*Neslia paniculata* (L.) Desv.*
*Raphanus raphanistrum* L.*
*Brassica juncea* (L.) Coss.*
*B. nigra* (L.) Koch*
*B. rapa* L.*
*Conringia orientalis* (L.) Dumort.*
*Alliaria officinalis* Andrz.*
*Sisymbrium officinale* (L.) Scop.*
*S. altissimum* L.*
*Arabidopsis thaliana* (L.) Heynh.
*Descurainia pinnata* (Walt.) Britt.*
*Erysimum cheiranthoides* L.*
*E. repandum* L.*
*Rorippa islandica* (Oeder) Borbas
*Nasturtium officinale* R. Br.
*Barbarea vulgaris* R. Br.
*B. verna* (Mill.) Aschers.
*Cardamine bulbosa* (Schreb.) BSP.
*C. douglassii* (Torr.) Britt.
*C. pensylvanica* Muhl.
*Arabis patens* Sulliv.
*A. laevigata* (Muhl.) Poir.

**Crassulaceae**
*Sedum acre* L.
*S. ternatum* Michx.
*S. telephium* L. (Earl, 1907)
*S. telephioides* Michx. (Earl, 1907)

**Saxifragaceae**
*Saxifraga virginiensis* Michx.
*S. pensylvanica* L.
*Tiarella cordifolia* L.
*Heuchera americana* L.
*Mitella diphylla* L.
*Chrysosplenium americanum* Schwein.

**Rosaceae**
*Fragaria virginiana* Duchesne
*Potentilla recta* L.
*P. norvegica* L.
*P. intermedia* L.
*P. simplex* Michx.
*Geum canadense* Jacq.
*G. virginianum* L.
*G. vernum* (Raf.) T. & G.
*Agrimonia gryposepala* Wallr.
*A. parviflora* Ait.

**Leguminosae**
*Trifolium pratense* L.
*T. repens* L.
*T. hybridum* L.
*Medicago lupulina* L.
*Vicia sativa* L.*
*V. angustifolia* Reichard*
*V. caroliniana* Walt.
*V. villosa* Roth

**Callitrichaceae**
*Callitriche heterophylla* Pursh

**Guttiferae**
*Hypericum punctatum* Lam.
*H. mutilum* L.

**Cistaceae**
*Lechea racemulosa* Lam.
**Violaceae**
*Viola papilionacea* Pursh
*V. sagittata* Ait.
*V. triloba* Schwein.
*V. blanda* Willd.
*V. striata* Ait.
*V. conspersa* Reichenb.
*V. rostrata* Pursh
**Cactaceae**
*Opuntia humifusa* Raf. (Earl, 1907)
**Onagraceae**
*Epilobium coloratum* Biehler
*E. glandulosum* Lehm.
*Oenothera biennis* L.
*Gaura biennis* L.
**Umbelliferae**
*Sanicula gregaria* Bickn.
*Chaerophyllum procumbens* (L.) Crantz
*Osmorhiza claytoni* (Michx.) C. B. Clarke
*O. longistylis* (Torr.) DC.
*Torilis japonica* (Houtt.) DC.
*Zizia aurea* (L.) W. D. J. Koch
*Cryptotaenia canadensis* (L.) DC.
*Thaspium trifoliatum* (L.) Gray
*T. barbinode* (Michx.) Nutt.
*Heracleum maximum* Bartr.
*Daucus carota* L.
**Pyrolaceae**
*Chimaphila umbellata* (L.) Nutt.
*C. maculata* (L.) Pursh
*Pyrola secunda* L. (Fernald, 1950)
*P. elliptica* Nutt.
*P. rotundifolia* L.
**Ericaceae**
*Epigaea repens* L.
*Gaultheria procumbens* L.
**Primulaceae**
*Trientalis borealis* Raf. (Earl, 1907)
*Samolus parviflorus* Raf.
*Lysimachia nummularia* L.
*L. ciliata* L.
**Gentianaceae**
*Sabatia angularis* (L.) Pursh
*Obolaria virginica* L.
**Apocynaceae**
*Vinca minor* L.
**Polemoniaceae**
*Polemonium reptans* L.
*Phlox divaricata* L.
*P. stolonifera* Sims
*P. paniculata* L.
**Hydrophyllaceae**
*Hydrophyllum canadense* L.
*H. appendiculatum* Michx.
*Phacelia purshii* Buckl.
**Boraginaceae**
*Lithospermum arvense* L.*
*Myosotis scorpioides* L.
*Lappula echinata* Gilib.*
**Labiatae**
*Glechoma hederacea* L.
*Prunella vulgaris* L.
*Leonurus cardiaca* L.
*Lamium amplexicaule* L.
*L. purpureum* L.
*L. maculatum* L. (Earl, 1907)
*L. album* L. (Earl, 1907)
*Salvia lyrata* L.
*Blephilia ciliata* (L.) Benth.
*B. hirsuta* (Pursh) Benth.
**Scrophulariaceae**
*Verbascum thapsus* L.
*V. blattaria* L.
*Veronica serpyllifolia* L.
*V. officinalis* L.
*V. peregrina* L.*
*V. arvensis* L.
*V. agrestis* L.*
*V. persica* Poir.*
*Castilleja coccinea* (L.) Spreng.
**Plantaginaceae**
*Plantago major* L.
*P. rugelii* Dcne.
*P. lanceolata* L.
*P. aristata* Michx.*
*P. virginica* L.
**Rubiaceae**
*Galium aparine* L.
*G. triflorum* Michx.
*G. pilosum* Ait.
*Mitchella repens* L.
*Houstonia caerulea* L.
*H. longifolia* Gaertn.
*H. canadensis* Willd.
**Caprifoliaceae**
*Linnaea borealis* L. (Fernald, 1950)
**Valerianaceae**
*Valerianella olitoria* (L.) Poll.*
*V. intermedia* Dyal
**Dipsacaceae**
*Dipsacus sylvestris* Huds.
**Campanulaceae**
*Campanula americana* L.
*Lobelia cardinalis* L.
*L. siphilitica* L.
*L. spicata* Lam.
*L. inflata* L.

**Compositae**

*Solidago caesia* L.
*S. flexicaulis* L.
*S. erecta* Pursh
*S. patula* Muhl.
*S. juncea* Ait.
*S. nemoralis* Ait.
*S. rugosa* Ait.
*S. gigantea* Ait.
*S. rigida* L.
*Aster divaricatus* L.
*A. macrophyllus* L.
*A. cordifolius* L.
*A. undulatus* L.
*A. prenanthoides* Muhl.
*A. puniceus* L.
*A. laevis* L.
*A. pilosus* Willd.
*A. lateriflorus* (L.) Britt.
*A. tradescanti* L.
*Erigeron pulchellus* Michx.
*E. philadelphicus* L.
*E. annuus* (L.) Pers.
*E. strigosus* Muhl.
*E. canadensis* L.*
*Antennaria plantaginifolia* (L.) Hook.
*Gnaphalium obtusifolium* L.
*G. purpureum* L.
*Polymnia canadensis* L.
*Rudbeckia laciniata* L.
*R. triloba* L.
*R. hirta* L.
*R. speciosa* Wend.
*Achillea millefolium* L.
*Anthemis cotula* L.*
*Matricaria maritima* L.*
*M. chamomilla* L.*
*Chrysanthemum leucanthemum* L.
*Senecio vulgaris* L.*
*S. aureus* L.
*S. obovatus* Muhl.
*Cirsium vulgare* (Savi) Tenore
*C. altissimum* (L.) Spreng.
*Centaurea cyanus* L.*
*Taraxacum officinale* Weber
*Lactuca scariola* L.
*L. canadensis* L.
*L. floridana* (L.) Gaertn.
*L. biennis* (Moench) Fern.
*Hieracium venosum* L.
*H. paniculatum* L.
*H. gronovii* L.

*Vegetative form.* Differences in degree of elongation of the internodes of the overwintering above-ground stems are responsible for the most pronounced differences in vegetative form. In most cases, the internodes are quite distinctly either elongated or not elongated.

Where internodes are clearly elongated, leaves are distinctly opposite, alternate, or whorled along the length of the stem. Stems may be branched or simple, and erect, ascending, decumbent, or prostrate. The terminal bud is rarely more than eight and usually less than five centimeters above ground. To this group belong the species of the following: *Cerastium*, *Sedum*, Leguminosae, *Epigaea*, *Gaultheria*, *Lysimachia* (*nummularia*), *Obolaria*, *Phlox*, Labiatae (except *Prunella* and *Salvia*), *Veronica*, Rubiaceae, *Chrysosplenium*, *Hypericum*, *Lechea*, and *Polymnia*. In a few cases, *e.g.*, *Chimaphila* spp., stems are elongate but the leaves are crowded near the tip, and in *Claytonia* there are but two leaves borne at the end of a fragile usually non-green stem which is several centimeters long. In *Houstonia caerulea*, stems are frequently highly branched forming a polster. For the most part, the vegetative form and vegetative characters of plants belonging to this group are essentially like those at other seasons of the year.

Where the internodes are not appreciably elongated, the leaves are crowded on short simple usually erect stems and may be ascending or prostrate. If the petioles are margined and shorter than the blades, and the leaves are prostrate and in a more or less radially symmetrical arrangement the plants are here referred to as having a rosette form. If the petioles are unmargined or margined and longer than the blades, or the leaves are not in a radially symmetrical arrangement, or they are ascending, the plants are said to have a tufted form. In both rosettes and tufts, the terminal bud is usually less than two centimeters above ground and the leaf arrangement is not readily evident. The short stem usually bears a few to several or many leaves; exceptions are *Aplectrum*, where there is but a single leaf, and *Solidago juncea* where usually only two principal leaves are present. Leaves of both rosettes and tufts are often quite different from those which appear on the elongated stems during the following growing season and are those which, when still persistent at time of flowering, are sometimes referred to in taxonomic works as the "basal leaves."

Species with well-developed flat rosettes are those of the following genera and families: *Goodyera*, Cruciferae (most), *Arabis* (*laevigata*), *Saxifraga* (*virginiensis*), *Agrimonia*, *Epilobium*, *Sabatia*, *Verbascum*, *Castilleja*, Plantaginaceae, *Dipsacus*, *Lobelia*, *Antennaria*, *Gnaphalium*, *Cirsium*, and *Lactuca*.

Tufted forms include: Gramineae, Cyperaceae, Juncaceae, Liliaceae, *Rumex*, *Dianthus*, *Corydalis*, Ranunculaceae, *Cardamine*, *Tiarella*, *Heuchera*, *Mitella*, *Fragaria*, *Potentilla*, *Viola*, Umbelliferae, *Pyrola*, *Lysimachia* (*ciliata*), *Polemonium*, *Hydrophyllum*, *Valerianella*, *Campanula*, *Aster*, *Solidago*, *Rudbeckia*, *Chrysanthemum*, and *Senecio* (*aureus*).

Species which are often difficult to classify as having either distinct rosettes or tufts are those of *Silene*, *Saxifraga* (*pensylvanica*), *Geum*, *Oenothera*, *Gaura*, *Salvia*, *Erigeron* (*annuus*), and *Hieracium*. In some, *e.g.*, *Phacelia*, *Leonurus cardiaca*, and *Houstonia* (*caerulea*, *longifolia*, and *canadensis*), the degree of internode elongation is variable. Watercress (*Nasturtium officinale*) is singular in that during much of the winter season individuals have elongated internodes, but by mid-February this population at least sometimes has been replaced by one consisting of distinct rosettes.

Approximately 47 percent of the species cited here as being winter-green occur as tufts; 23 percent have a rosette form; 20 percent have elongated internodes; six percent occur as either tufts or rosettes; and four percent may have elongated internodes or not, depending apparently upon environmental conditions during the autumn and winter seasons.

*Time of appearance of the winter leaves.* The winter-green species are biennials and perennials: 73 percent are perennials, 35 percent biennials, and two percent biennials and under certain conditions perennials. Examples of the last group are *Rudbeckia triloba*, *Lychnis alba*, *Ranunculus abortivus*, and *Oenothera biennis*, specimens of all of which were perennial for four years or longer in the Botanical Garden. Species described in weed manuals and other publications as "winter annuals" have life cycles spanning two growing seasons, and hence are biennials in the sense that a biennial is one in which germination of the embryo takes place during one growing season and flowering and death occur in the subsequent growing season.

The overwintering leaves of biennials (and first-year perennials) apparently are those formed during summer or autumn growth following germination of the embryo. The winter leaves may persist at the time of flowering, although usually by this time they have disappeared or are present only as remnants.

Perennials exhibit a wide range of variation in time of appearance of the overwintering leaves. In some of the spring-flowering species, *e.g.*, *Hepatica* spp. and *Saxifraga virginiensis*, the leaves which will overwinter appear during flowering or shortly thereafter, and persist until the following spring. In others, *e.g.*, *Cardamine bulbosa* and *Isopyrum biternatum*, the old winter leaves die by early summer along with the spring growth, and new winter leaves appear during the autumn. This growth regime, characterized by the presence of leaves in the autumn, winter and spring months is found, with variations in the time of appearance and death of the leaves, in a number of other species, *e.g.*, *Claytonia virginica*. In this species the winter leaves begin growth in early winter and continue until time of flowering in April, after which death of the above-ground parts occurs.

In a number of spring-flowering species, the summer and winter leaves have essentially the same appearance, and the latter are apparently merely those which are present when the winter season commences. Examples of this group are *Sedum ternatum*, *Fragaria virginiana*, and *Houstonia caerulea*. Winter leaves of such summer-flowering species as *Potentilla* spp. and *Lysimachia nummularia* also do not appear to be the result of growth occurring during a period specifically related to the time of flowering or to the changing autumn environment.

In still others among the spring-flowering species, *e.g.*, *Viola* spp., the winter leaves appear at a definite time in late summer or autumn, accompanied by death of the summer leaves.

Among summer- and autumn-flowering perennial species, the winter leaves first appear by far most frequently during flowering or soon thereafter, continue growth as long as favorable environmental conditions prevail, and persist until the following spring or in some cases into summer. All such tufts or rosettes are in reality branches arising from buds usually near the below-ground base of the old stem—"basal offshoots" of some authors—and the time of formation

of these vegetative buds (or those of spring-flowering species as well) is unknown in most cases. Examples of this group are *Aster* and *Solidago* spp., *Rudbeckia* spp., *Lobelia* spp., and *Anemone virginiana*.

The overwintering leaves of both biennials and perennials are frequently distinctly different in appearance from the leaves present at other seasons. In other cases they are similar but at variance in some respects, and in still others the overwintering leaves are indistinguishable from those of other seasons. These seasonal differences have been described only in isolated instances, even monographers usually failing to mention them. A notable exception is the treatment of the genus *Heuchera* by Rosendahl *et al.* (1936), who state that "Often the leaves produced in the late summer, which usually persist throughout the winter, are of quite different size and shape from those produced during active growth in the spring." Failure to describe these seasonal variations in leaves is apparently due to the practice of limiting observation largely or entirely to plants in the flowering condition. As a result, the growth regimes of winter-green and most other herbaceous species, as well, are imperfectly known.

## ECOLOGY OF THE WINTER FLORA

Daily, seasonal, and annual regimes of the major weather elements, as measured by official agencies and as referred to in most ecological reports, bear slight resemblance to actual environmental conditions surrounding plants in the lowest layer of air (Wolfe, 1944). Especially is this true of above-ground parts of plants during winter. An intensive study of environmental conditions was not within the scope of this investigation, but attention is here called to some general conditions and certain problems associated with the ecology of the winter-greens.

Solar radiation is a major weather control, and in local situations is especially important in relation to air and soil temperatures, and consequently to the rates of processes in plants. On the forest floor insolation during the winter months is never less than five times greater than that in mid-July (Wolfe, *et al.*, 1949). A conspicuous increase in light intensity during October and November, and rapid decrease during April and May, result respectively from disappearance of the canopy and its closure. Light intensities during the winter months are probably more than adequate for photosynthesis.

Because of this insolation, temperatures of plants themselves may be higher during the daytime than air temperatures a few feet above them. Likewise, minimum temperatures of plants are ordinarily lower than those of this air during the night or other times when radiation exceeds insolation. Since official Weather Bureau air temperatures are not usually those of the air surrounding plants (Wolfe, *et al.*, 1949), the range of temperature to which the above-ground parts of plants are subjected in winter, as a result of fluctuating air temperatures and insolation and radiation, can only be guessed until actual measurements of the temperatures of the plants themselves are made.

Temperatures to which winter leaves of plants are exposed range from well below freezing to considerably above freezing. This range is greater in fully exposed habitats, such as cliff faces and denuded roadside banks, than in forest communities where plants are commonly surrounded by leaf litter. Even in forest conditions the leaves may be frozen solid at times during daylight hours. Those of *Dianthus armeria* and *Epilobium coloratum*, both pioneer species, have been found a number of times frozen so solidly that a slight touch was sufficient to break off a leaf. That temperatures are often low enough to freeze above-ground parts, in nearly any natural habitat in Ohio, and yet not result in death of these organs, has been observed many times in the field.

Lowest minimum temperatures to which these plants are exposed, and highest maximums, occur where insolation in daytime and radiation at night are greatest. In forest habitats, leaf litter conditions modify minimum temperatures upwards. In fully exposed situations, minimums may conceivably be less than 0°F on certain

winter nights. Exposure to the most extreme minimums rarely occurs in any habitat of an area, since these extremes almost always follow snowfall (Dole, 1927, and Beatley, 1953). Under snow, temperatures remain essentially uniform day and night. In the absence of snow, however, temperatures of exposed parts of plants may sometimes rise well above freezing in the daytime even if air temperature is below 32°F. What maximum temperatures plant tissues may attain is not known, but during daylight hours they must often be considerably above 32°F, as evidenced by widespread thawing of adjacent substrates and melt-water on cliff faces.

Underground parts of forest plants are rarely, if ever, exposed to sub-freezing temperatures since the soil beneath even a moderately deep leaf litter rarely freezes (Wolfe, 1949). Where leaf litter is scanty or absent, soils may be frozen solid during certain periods. Since the temperatures of roots and other underground organs are essentially the same as the surrounding soil, the below-ground tissues are either never frozen or frozen only during certain periods. While upper soil temperatures are lower in winter than in other seasons, and while water absorption may be reduced under these conditions, it probably does not cease as long as the soil is unfrozen. That availability of water may be a factor in the distribution of winter-greens is indicated by the nature of vegetation along stream banks and in other wet or moist habitats. Here plants are most abundant in the winter, best developed, and the brightest green. Water relations in winter-green herbs, especially absorption and transpiration, seem worthy of study out-of-doors, or at least under simulated field conditions.

A discussion of the physiology of winter-greens is beyond the scope of this paper, but two processes which appear to have possible ecological significance should be mentioned, *viz.*, photosynthesis and growth. Although winter photosynthesis is not known to have been measured in native herbaceous plants, there is no reason to assume that it does not occur since light intensities are not limiting, daytime temperatures some of the time (perhaps much of the time) are not unfavorable, and water absorption can occur in forest plants the winter through and in others at least during certain periods. If photosynthesis occurs in winter, even intermittently, a new field of problems becomes apparent, including the importance of this process in winter to the survival of plants in which it occurs, and its significance in certain problems of plant distribution.

It is certain from both field inspection and observations of plants transplanted to the Botanical Garden, that growth of leaves occurs in the Ohio region during winter both under snow cover and exposed. The so-called growing season appears from these observations to be in reality a period of accelerated growth, while the winter season, at least for some species, is one of merely decelerated growth. Actual measurements of rates of winter growth, its periodicity, conditions under which it occurs, its physiological significance, and its relation to plant distribution are problems which have been investigated as yet in only isolated instances.

That a period of low temperatures is often requisite to the breaking of dormancy[2] of many native perennials, and certain biennials as well, has been clearly indicated by attempts to force flowering in greenhouse conditions during this study. Similar observations of native perennial species were made by Rosendahl (1914) a number of years ago. Examples of species for which a cold period, or its equivalent, was found necessary in the present study are *Lobelia cardinalis*, *Dianthus armeria*, *Hieracium* spp., and most species of *Aster and Solidago*. Measurements of degree and duration of low temperatures requisite to the breaking of dormancy in native herbaceous plants have not been made. Also, alternating

[2]The dormant condition, as used in this paper, refers to the winter vegetative condition. Breaking of dormancy refers to elongation of the stems of tufts and rosettes, and to initiation of flower primordia in plants with elongated internodes in the winter condition.

periods of low and relatively higher temperatures, which may be factors in breaking of dormancy, are open to further investigation. The minimum duration and degree of low temperatures, and alternating "cold" and "warm" periods necessary for each species can be expected to differ widely. Whatever these requisites are, they apparently are satisfactorily met within the diverse microclimates in which native species of the Ohio region pass the winter.

The full extent to which effects of low temperatures on the processes related to dormancy are controlling factors in plant macrodistribution can only be surmised. Local distribution may also be related to the particular winter conditions necessary to fulfill very specific requirements of some species during the dormant period. These winter conditions may prevail only in certain microhabitats. The local distribution of some species, regardless of their possible ecological amplitude at other seasons, may conceivably be limited by the environmental complexes which characterize winter microclimates. The study of these conditions, using winter-green species, may prove a fruitful approach to local distribution problems.

The extent to which all of the species enumerated here are winter-green in all habitats in which they may grow is unknown. Most, especially the native forest species, are believed to have winter leaves in most, if not all, of the habitats in which the species occur. A single exception is known: *Viola papilionacea* is winter-green in certain valleys of Fairfield and Hocking Counties, but does not appear to be so in swamp forests of the Columbus area. Whether such variation in behavior is due to genotypic or environmental differences, or both, is not known; it can only be said, on the basis of present information, that within each of the species there must be at least some biotypes in which the potentiality of winter-greenness is expressed in at least some environments. It is suggested that, in general, species of relatively broad ecological amplitudes are those most likely to be demonstrated not to be winter-green in all habitats in which they occur.

*Ecological classification of the winter-green species.* The herbaceous winter-greens may be classified in a general way on the basis of their association with the major vegetation types. The numbers of species and abundance of individuals which make up the winter ground cover societies vary conspicuously among the vegetation types. In the Oak-Chestnut association, species are numerous but individuals usually occur as scattered specimens and are nowhere abundant. This is generally true also of Beech-Sugar Maple forests, where number of species and individuals is somewhat correlated with degree of disturbance. Of the forest communities, number of species is greatest and individuals are most abundant in swamp forests. Greatest paucity of species occurs in Hemlock and Hemlock-Beech communities, where but one species, *Mitchella repens*, together with Christmas Fern (*Polystichum acrostichoides*), constitutes the ground layer society the year around. In general, it is in the pioneer habitats such as old fields and their developmental stages, and unforested flood plains and stream banks, in which the greatest diversity of the winter flora occurs; here also individuals are most abundant. In these pioneer sites, the ground may be locally nearly carpeted with green throughout the winter season.

In the ecological classification which follows, those which are referred to as "common" generally occur in most communities with which they are associated, though they may not necessarily be abundant. Species considered as "frequent to infrequent" are those which may occasionally occur in these vegeatation types, or may be almost common under certain conditions. Species introduced into Ohio are indicated by (I).

Swamp Forest communities, including such developmental societies as are found in marshes, swales, wet old fields and sandbars, as well as the strictly arboreal communities of Sycamore-Cottonwood-Willow, Elm-Ash-Soft Maple, Mixed Swamp Forest, and their related types.

Common to abundant:

*Elymus virginicus*
*Stellaria media* (I)
*Claytonia virginica*
*Ranunculus abortivus*
*Barbarea vulgaris* (I)
*Geum canadense*
*Agrimonia parviflora*
*Viola striata*
*Chaerophyllum procumbens*
*Osmorhiza claytoni*
*O. longistylis*
*Lysimachia nummularia* (I)
*L. ciliata*
*Glechoma hederacea*
*Galium aparine*
*G. triflorum*
*Valerianella intermedia*
*Aster cordifolius*
*A. prenanthoides*
*A. lateriflorus*
*Senecio obovatus*
*S. aureus*

Frequent to infrequent:

*Cinna arundinacea*
*Hystrix patula*
*Panicum* spp.
*Carex plantaginea*
*C. gracilescens*
*Juncus effusus*
*Allium vineale* (I)
*Stellaria longifolia*
*Cerastium vulgatum* (I)
*C. nutans*
*C. viscosum* (I)
*Ranunculus sceleratus*
*R. recurvatus*
*R. septentrionalis*
*Isopyrum biternatum*
*Rorippa islandica*
*Cardamine bulbosa*
*C. douglassii*
*C. pensylvanica*
*Geum virginianum*
*G. vernum*
*Agrimonia gryposepala*
*Hypericum punctatum*
*H. mutilum*
*Viola papilionacea*
*Epilobium coloratum*
*Sanicula gregaria*
*Zizia aurea*
*Cryptotaenia canadensis*
*Thaspium trifoliatum*
*T. barbinode*
*Heraceum maximum*
*Polemonium reptans*
*Vicia caroliniana*
*Hydrophyllum canadense*
*Phacelia purshii*
*Prunella vulgaris* (I)
*Leonurus cardiaca* (I)
*Lamium purpureum* (I)
*L. amplexicaule* (I)
*Blephilia hirsuta*
*Lobelia cardinalis*
*L. siphilitica*
*Solidago flexicaulis*
*S. patula*
*S. rugosa*
*Aster puniceus*
*A. tradescanti*
*Erigeron pulchellus*
*E. philadelphicus*
*Polymnia canadensis*
*Rudbeckia laciniata*
*Lactuca canadensis*

Rare:

*Saxifraga pensylvanica*
*Viola conspersa*
*Samolus floribundus*
*Phlox stolonifera*

Beech-Sugar Maple association and its borders.

Common:

*Silene virginica*
*Claytonia virginica*
*Hepatica acutiloba*
*H. americana*
*Heuchera americana*
*Mitella diphylla*
*Osmorhiza claytoni*
*O. longistylis*
*Phlox divaricata*
*Galium aparine*
*G. triflorum*
*Mitchella repens*
*Solidago caesia*
*Aster cordifolius*

Frequent to infrequent, or common locally:

*Carex* spp.
*Ranunculus abortivus*
*R. recurvatus*
*Anemone virginiana*
*Isopyrum biternatum*
*Stellaria longifolia*
*Cardamine douglassii*
*Tiarella cordifolia*
*Geum canadense*
*G. virginianum*
*Viola papilionacea*
*V. rostrata*
*Cryptotaenia canadensis*
*Obolaria virginica*
*Polemonium reptans*
*Hydrophyllum canadense*
*H. appendiculatum*
*Blephilia hirsuta*
*Solidago flexicaulis*
*Aster macrophyllus*
*Erigeron pulchellus*
*Senecio obovatus*

Mixed Mesophytic or Hemlock-Hardwood associations or both.

Common:

*Mitchella repens* *Aster divaricatus* *A. cordifolius*

Frequent to rare, or common locally:

*Goodyera pubescens*
*Aplectrum hyemale*
*Tiarella cordifolia*
*Heuchera americana*
*Chrysosplenium americanum*
*Viola blanda*
*Coptis groenlandica*
*Pyrola rotundifolia*
*P. elliptica*
*P. secunda*
*Galium aparine*

Oak associations, including Oak-Chestnut, Oak-Hickory, and Oak-Pine, and their borders.

Common:

*Panicum lanuginosum*
*Saxifraga virginiensis*
*Heuchera americana*
*Fragaria virginiana*
*Potentilla simplex*
*Epigaea repens*
*Gaultheria procumbens*
*Mitchella repens*
*Solidago caesia*
*Aster cordifolius*
*Antennaria plantaginifolia*

Frequent to infrequent:

*Hystrix patula*
*Panicum* spp.
*Carex* spp.
*Luzula campestris*
*L. acuminata*
*Chamaelirium luteum*
*Goodyera pubescens*
*Silene virginica*
*S. pensylvanica*
*Hepatica acutiloba*
*H. americana*
*Anemone virginiana*
*Sedum ternatum*
*Vicia caroliniana*
*Viola triloba*
*Chimaphila umbellata*
*C. maculata*
*Sabatia angularis*
*Obolaria virginica*
*Phlox divaricata*
*Arabis laevigata*
*Salvia lyrata*
*Blephilia ciliata*
*Veronica officinalis*
*Galium pilosum*
*Houstonia longifolia*
*Lobelia inflata*
*L. spicata*
*Solidago nemoralis*
*S. erecta*
*Aster macrophyllus*
*Gnaphalium* spp.
*Senecio oboatus*
*Hieracium venosum*
*H. paniculatum*
*H. gronovii*

Crevice, Ledge, Cliff Face, or Cliff Top communities.

*Silene rotundifolia*
*Hepatica americana*
*H. acutiloba*
*Aquilegia canadensis*
*Corydalis flavula*
*Arabis patens*
*A. laevigata*
*Sedum ternatum*
*Saxifraga virginiensis*
*Lechea racemulosa*
*Epigaea repens*
*Houstonia longifolia*
*Aster laevis*

Old Fields and developmental phases, including lawns, pastures, roadsides and cultivated grounds.
Common to abundant:

*Bromus* spp. (I)
*Danthonia spicata*
*Andropogon virginicus*
*Allium vineale* (I)
*Rumex* spp. (I)
*Stellaria media* (I)
*Cerastium vulgatum* (I)
*Dianthus armeria* (I)
*Ranunculus abortivus*
*Lepidium virginicum*
*Capsella bursa-pastoris* (I)
*Barbarea vulgaris* (I)
*Fragaria virginiana*
*Potentilla norvegica*
*P. simplex*
*Trifolium* spp. (I)
*Medicago lupulina* (I)
*Oenothera biennis*
*Daucus carota* (I)
*Prunella vulgaris* (I)
*Leonurus cardiaca* (I)
*Verbascum thapsus* (I)
*V. blatteria* (I)
*Veronica officinalis*
*V. serpyllifolia*
*V. arvensis* (I)
*Plantago major* (I)
*P. rugelii*
*P. lanceolata* (I)
*Dipsacus sylvestris* (I)
*Solidago nemoralis*
*S. juncea*
*Aster pilosus*
*Erigeron annuus*
*E. strigosus*
*Antennaria plantaginifolia*
*Gnaphalium obtusifolium*
*Achillea millefolium*
*Chrysanthemum leucanthemum* (I)
*Cirsium vulgare*
*Taraxacum officinale* (I)
*Lactuca* spp.

Frequent to infrequent, or common only locally:

*Arenaria serpyllifolia* (I)
*Cerastium nutans*
*Agrostemma githago* (I)
*Lychnis alba* (I)
*Silene antirrhina*
*Draba verna* (I)
*Brassica* spp. (I)
*Sisymbrium* spp. (I)
*Arabidopsis thaliana* (I)
*Potentilla recta* (I)
*Vicia* spp. (except *V. caroliniana*) (I)
*Viola sagittata*
*Gaura biennis*
*Sabatia angularis*
*Lithospermum arvense* (I)
*Blephilia ciliata*
*Plantago aristata*
*P. virginica*
*Houstonia caerulea*
*H. longifolia*
*H. canadensis*
*Lobelia spicata*
*L. inflata*
*Solidago rugosa*
*S. rigida*
*Aster laevis*
*Erigeron philadelphicus*
*Gnaphalium purpureum*
*Rudbeckia hirta*
*R. triloba*
*R. laciniata*
*Hieracium gronovii*

Prairie communities.

*Salvia lyrata*
*Blephilia ciliata*
*Castilleja coccinea*
*Houstonia longifolia*
*H. canadensis*
*Lobelia spicata*
*Solidago nemoralis*
*S. rigida*
*Aster pilosus*
*Rudbeckia hirta*
*R. triloba*
*R. speciosa*

---

## KEY TO THE WINTER-GREEN HERBACEOUS FLOWERING PLANTS OF CENTRAL AND SOUTHERN OHIO[3]

1. Leaves longitudinally veined ..... 2
1. Leaves not longitudinally veined ..... 12
   2. Leaves with split or closed sheaths, blades grass-like, many times longer than broad (except in *Panicum* spp.), many-veined ..... 3
   2. Leaves without sheaths, blades usually not grass-like ..... 5
3. Blades ending in a gland-like tip, leaf sheaths closed; more or less webbed-hairy .. *Luzula* spp.
3. Blades not ending in a gland-like tip, or if so, leaf sheaths split or open ..... 4
   4. Leaves with sheaths split on the side opposite the blade, 2-ranked ..... Gramineae
   4. Leaves with closed sheaths, 3-ranked ..... Cyperaceae
5. Leaves hollow, circular in cross-section, sometimes grooved on upper side, with a strong onion odor, up to 40 cm. long ..... *Allium vineale*
5. Leaves flat, not hollow ..... 6
   6. Blades grass-like, 2–6 mm. broad, 3-veined, narrowed to short, slender, margined petioles ..... *Plantago aristata*
   6. Blades not grass-like ..... 7
7. Leaves solitary, plaited, erect ..... *Aplectrum hyemale*
7. Leaves not solitary, several to many in a more or less flat rosette ..... 8
   8. Leaves dark green with 5–7 white main veins and many fine white reticulating veins ..... *Goodyera pubescens*
   8. Leaves not white-veined ..... 9
9. Leaves villous-pubescent; obovate, oblong or linear; prairies ..... *Castilleja coccinea*
9. Leaves not villous, but glabrous or pubescent ..... 10
   10. Blades narrowly oblong to lanceolate, less than 2.5 cm. broad, with tufts of long matted brownish or whitish hairs at the bases of the petioles .... *Plantago lanceolata*
   10. Leaves spatulate, mostly more than 2.5 cm. broad ..... 11
11. Blades bright or pale green, tapering into margined petioles shorter than the blades, entire, smooth and glabrous, more than 7-veined (usually many-veined); forest species, rare except locally ..... *Chamaelirium luteum*
11. Blades dark green, abruptly narrowed into stout, unmargined, channelled petioles about the same length as or shorter than the blades, entire, undulate, or shallowly dentate, glabrous or sparingly pubescent, 5–7-veined; common weed of lawns, roadsides and waste grounds ..... *Plantago major*
    *P. rugelii*
   12. Leaves very finely 2–3-pinnately dissected, the ultimate segments (or lobes) linear or narrowly linear-lanceolate, rarely more than 1 mm. broad, the leaves with a feathery appearance; plants with a strong odor; weeds of roadsides, fields, and waste grounds ..... 13
   12. Leaves not finely 2–3-pinnately dissected as above ..... 15
13. Blades with 12–30 pairs of primary divisions; ultimate segments linear-oblong, less than 1 mm. broad, blades 2–5 cm. broad; horizontal rhizome ..... *Achillea millefolium*

[3]Based upon winter field characters.

13. Blades with fewer than 10 pairs of primary divisions ..... 14
    14. Plants with a long, stout, fleshy taproot, ultimate leaf segments or lobes about 1 mm. broad, leaves more than 5 cm. long, petioles long and slender, leaves tufted ..... *Daucus carota*
    14. Plants not with a long, fleshy taproot, ultimate leaf segments linear or filiform, usually less than 0.5 mm. broad, leaves sessile or nearly so, 2–5 cm. long, alternate on short, simple or branched stems ..... *Anthemis cotula*
15. Leaves compound, or so deeply divided as to appear compound, the segments distinct or nearly so ..... 16
15. Leaves simple ..... 54
    16. Most of the leaves ternately compound, ternately decompound, or simple but 3-divided (*i.e.*, with 3 distinct segments) ..... 17
    16. Leaves not ternately compound, ternately decompound, or 3-divided ..... 33
17. Blades biternate ..... 18
17. Blades once-ternate ..... 23
    18. Ultimate leaflets pinnatifid with oblong, obtuse lobes 1–7 mm. long, 1–3 mm. broad, sheath with a scarious, villous margin ..... *Chaerophyllum procumbens*
    18. Ultimate leaflets not pinnatifid ..... 19
19. Plants, especially the roots, with an anise or licorice odor; leaflets coarsely serrate, dentate or incised, sparingly or densely pubescent throughout ..... *Osmorhiza* spp.
19. Plants not with an anise or licorice odor ..... 20
    20. Ultimate leaflets ovate, acute at the apex, sharply serrate, and if lobed, the lobes acute ..... 21
    20. Ultimate leaflets wedge-shaped, obtuse at the apex and obtusely lobed, not serrate ..... 22
21. Leaflets sharply and closely serrate ..... *Zizia aurea*
21. Leaflets coarsely serrate or incised ..... *Thaspium barbinode*
    22. Leaflets mostly longer than 1.5 cm., the lobes not mucronate, veins usually inconspicuous above, glabrous to softly pubescent ..... *Aquilegia canadensis*
    22. Leaflets mostly less than 1.5 cm. long, lobes minutely mucronate, veins prominent above, smooth and entirely glabrous ..... *Isopyrum biternatum*
23. Leaves alternate on stems with elongated internodes, leaflets denticulate or serrulate ... 30
23. Leaves tufted, leaflets serrate, dentate, crenate, or incised, always conspicuously toothed .. 24
    24. Petioles without definite stipules, although usually dilated into membranous-margined bases and sheathing ..... 25
    24. Petioles with definite stipules ..... 29
25. Blades mostly broader than long, leaflets variously cleft into sharply toothed lobes, short-stalked or sessile; chiefly in Beech-Sugar Maple or Oak-Chestnut woods ..... *Anemone virginiana*
25. Blades not mostly broader than long ..... 26
    26. Petioles densely long-pubescent, hollow, strongly dilated at the base; terminal leaflet broadly ovate or orbicular in outline, commonly 3-lobed, 6–12 cm. broad, laterals smaller, broadly ovate, 2–3-lobed, all bluntly or acutely toothed, stalked; swamp forests and other moist grounds ..... *Heracleum maximum*
    26. Petioles not densely long-pubescent, hollow, or strongly dilated at the base, or if so, not otherwise as above ..... 27
27. Leaflets closely, sharply, and doubly serrate, the terminal one abruptly narrowed into a margined, toothed stalk or less commonly cuneate at the base, leaflets thin, glabrous ..... *Cryptotaenia canadensis*
27. Leaflets not as above ..... 28
    28. Leaflets finely, regularly and closely crenate-dentate, ovate or ovate-lanceolate, cordate at the base and the lateral usually strongly oblique, sessile or short-stalked, the terminal long-stalked, smooth and glabrous, thickish ..... *Thaspium trifoliatum*

28. Leaflets coarsely serrate, cleft into 2–3 broad lobes which in turn are usually lobed or incised, sparingly pubescent or glabrate, thin.... *Ranunculus septentrionalis*

29. Stipules membranous, white, ovate-oblong, about 0.5 cm. broad and 1 cm. long, entire, sparingly hirsute or glabrate; leaflets coarsely serrate..... *Fragaria virginiana*

29. Stipules greenish, lanceolate-oblong, 1 mm. or less broad, less than 1 cm. long, dentate, hirsute; blades coarsely incised-serrate..... *Potentilla norvegica*

30. 6–12 veins on either side of the midvein of each leaflet, stipules ovate or lanceolate, dentate or entire, blades pinnately 3-foliate..... *Medicago lupulina*

30. 20–30 veins on either side of the midvein of each leaflet, stipules not dentate, leaflets all from the same point..... 31

31. Leaflets finely denticulate; stipules ovate, leaves more or less pubescent and usually with a pale spot on the upper side..... *Trifolium pratense*

31. Leaflets serrulate with sharp-pointed, spine-like teeth; stipules ovate-lanceolate, blades glabrous, usually not with a pale spot on the upper side..... 32

32. Stems creeping and rooting at the nodes, stipules mostly less than 1 cm. long.. ..... *Trifolium repens*

32. Stems ascending or decumbent, stipules mostly 1–2 cm. long... *Trifolium hybridum*

33. Blades digitately 5–7-foliate..... 34

33. Blades not digitately 5–7-foliate..... 36

34. Stipules adnate to bases of the petioles, tips free; blades 5–7-foliate, more or less villous-pubescent, especially below..... 35

34. Petioles expanded at the base and sheathing, but not with stipules; blades 5-foliate, the leaflets thin, distinct or commonly the lateral slightly united at the base, all about the same size, wedge-shaped or obovate, 2–6 cm. long, sharply and mostly doubly serrate with bristle-tipped teeth, glabrous.... *Sanicula gregaria*

35. Leaflets (exclusive of stalks) mostly 1–3 cm. long, obovate or oval, coarsely serrate, commonly glossy, dark green above, firm and thickish, usually ascending..... ..... *Potentilla simplex*

35. Leaflets (exclusive of stalks) mostly 3–6 cm. long, oblanceolate or oblong-lanceolate, not glossy, bright green, thin and flaccid, incised-dentate with divergent teeth, spreading on the ground..... *Potentilla recta*

36. Blades pinnately decompound..... 37

36. Blades once-pinnately compound or divided..... 41

37. Petioles dilated into membranous-margined bases..... 38

37. Petioles not dilated as above; blades rather finely dissected into linear, oblong or wedge-shaped segments, acutely or obtusely toothed or lobed, pale green, glabrous, slender-petioled..... *Corydalis flavula*

38. Plants, especially the roots, with an anise or licorice odor; leaflets coarsely serrate, dentate or incised, sparingly or densely pubescent throughout..... ..... *Osmorhiza* spp.

38. Plants not with an anise or licorice odor..... 39

39. Ultimate leaflets pinnatifid with oblong, obtuse lobes 1–3 mm. broad, sheath with a scarious, villous margin..... *Chaerophyllum procumbens*

39. Ultimate leaflets broad, not pinnatifid..... 40

40. Leaflets sharply and closely serrate..... *Zizia aurea*

40. Leaflets coarsely serrate or incised..... *Thaspium barbinode*

41. Leaves even-pinnate, alternate on trailing, branched, weak stems, rachises terminating in slender tendrils, leaflets small..... 42

41. Leaves odd-pinnate, *i.e.*, with a terminal leaflet..... 44

42. Tendrils forked; fields, roadsides and waste places..... 43

42. Tendrils mostly unforked (simple); woodland borders..... *Vicia caroliniana*

43. Leaves and stem villous-pubescent..... *Vicia villosa*

43. Leaves glabrous or glabrate..... *Vicia sativa* *V. angustifolia*

44. Plants strictly aquatic, usually in small streams or at outlets of springs, many plants occurring together and covering the water surface; leaves not in rosettes (except in late winter), 3–9 leaflets, terminal one larger than the lateral and nearly orbicular ..... *Nasturtium officinale*
44. Plants terrestrial, or if growing in water, then in distinct, usually symmetrical rosettes ..... 45

45. Petioles with distinct stipules adnate to the base, the tips free; principal leaflets not varying greatly in size, deeply serrate, with small, interposed leaf segments ..... 46
45. Petioles without stipules, or if present, not otherwise as above ..... 47

46. Principal leaflets 11–17, close together and crowded ..... *Agrimonia parviflora*
46. Principal leaflets mostly 5 or 7, not crowded or close together ..... *Agrimonia gryposepala*

47. Terminal leaflet sharply 3- or 5-lobed ..... 48
47. Terminal leaflet not 3–5-lobed, or (in *Geum* spp.) the lobes rounded and usually shallow .. 49

48. Leaves large, 10–20 cm. long, 6–14 cm. broad, 3–7-divided, the lowest lateral leaflets the longest, 3–7 cm. long, all sharply and coarsely toothed, acutely lobed or incised ..... *Rudbeckia laciniata*
48. Leaves 2–5 cm. long, 1–2 cm. broad, 5–11-divided, the lowest lateral leaflets the smallest, less than 0.5 cm. long, all entire or sparingly toothed, obtuse or acute at the apex ..... *Phacelia purshii*

49. Roots, petioles and veins with bright orange or yellow sap; leaflets mostly 7, obovate or ovate, 2–3.5 cm. long, 1–2.5 cm. broad, crenate-lobed, the lobes or teeth all very obtuse, petioles dilated at the base and clasping ..... *Chelidonium majus*
49. Plants not with bright orange or yellow sap, or if so, not otherwise as above ..... 50

50. Terminal leaflet about the same size as the laterals; leaflets 3–7 pairs and the terminal one, elliptic or ovate, 0.5–2 cm. long, entire, glabrous, sessile ..... *Polemonium reptans*
50. Terminal leaflet conspicuously larger than the lateral ..... 51

51. Leaves more or less softly pubescent all over; 3–7 principal leaflets, with or without small interposed segments, ovate or obovate, more or less shallow round-lobed or incised, dentate or crenate ..... *Geum* spp.
51. Leaves glabrous ..... 52

52. Terminal leaflet orbicular, 2–5 cm. broad, cordate or rounded at the base, rosettes glossy dark green ..... 53
52. Terminal leaflets obovate, less than 2 cm. broad, narrowed at the base, rosettes bright green and not shining; 2–8 pairs of lateral leaflets .... *Cardamine pensylvanica*

53. 1–4 pairs of lateral leaflets ..... *Barbarea vulgaris*
53. 4–8 pairs of lateral leaflets ..... *Barbarea verna*

54. Leaves opposite, alternate, or whorled on a simple or branched stem with distinct internodes (in *Houstonia* spp. internodes short but usually leaves borne on minutely branched stems) ..... 55
54. Leaves in a flat rosette or tufted, stems always simple and with greatly reduced internodes ..... 95

55. All or some of the leaves verticillate ..... 56
55. Leaves all opposite or alternate ..... 62

56. Leaves verticillate in 3's, thick and succulent; light green, 0.5–2 cm. long, usually crowded at the end of the stem ..... *Sedum ternatum*
56. Leaves not verticillate in 3's, or if so, not thick and succulent ..... 57

57. Leaves all verticillate on weak, 4-angled stems in 4's, 6's, or 8's, more than one whorl on each stem ..... 58
57. Stems not 4-angled, leaves not all verticillate, or if so, stems not as above ..... 60

58. Leaves rather densely hirsute or pubescent, punctate, all in 4's; oval to ovate, eastern Ohio ..... *Galium pilosum*
58. Leaves glabrous or glabrate except for the margins or midveins, in whorls of 6 or 8, or the older ones commonly in 4's ..... 59

59. Biennial, plants very fragile, cotyledons persistent; leaves 0.5–3 cm. long, usually at least some of them in 6's or 8's, mucronate, stems sometimes hairy at the nodes..... *Galium aparine*

59. Perennial, usually many branches arising from the base, stems slender but not extremely fragile; leaves 0.5–1.5 cm. long, usually most of them in 6's, strongly mucronate..... *Galium triflorum*

60. Leaves mostly opposite with some verticillate on the same stem, less than 1 cm. long, not coriaceous, entire..... *Lechea racemulosa*

60. Leaves verticillate or scattered on the suberect stem, 1–8 cm. long, coriaceous, serrate..... 61

61. Leaves mottled with white along the veins, 2.5–8 cm. long, ovate or ovate-lanceolate.... *Chimaphila maculata*

61. Leaves not mottled, dark green and shining, 1–5 cm. long, spatulate or cuneate-oblanceolate..... *Chimaphila umbellata*

62. Leaves alternate..... 63

62. Leaves opposite..... 66

63. Blades sharply and rather shallowly serrate; lanceolate, prominently 3-veined, smooth and glabrous except for the rough margins and ciliate petioles, acute or subacuminate at the apex, gradually tapering into short, margined petioles, internodes only slightly elongated; swamp forests or moist pioneer sites..... *Solidago gigantea*

63. Blades entire..... 64

64. Leaves thin; bright green, oblong to oblanceolate, 1–6 cm. long; marshy places... *Myosotis scorpioides*

64. Leaves thick and more or less coriaceous; stem somewhat woody..... 65

65. Leaves clustered (mostly in 3's) at the ends of creeping branches, dark green, shining above, pale beneath, blades oval, oblong, or obovate..... *Gaultheria procumbens*

65. Leaves not appearing clustered, bright or dark green above, not pale beneath or shining above, dull, blades oval or nearly orbicular, often forming large patches..... *Epigaea repens*

66. Stems strongly and distinctly 4-angled, not twisted..... 67

66. Stems not 4-angled, or (in *Lysimachia*) obscurely so and slightly twisted..... 71

67. Blades 3–5 palmately lobed, 2–8 cm. long and nearly as broad; blades very veiny, lobes acute or acuminate, incised or dentate..... *Leonurus cardiaca*

67. Blades not lobed, mostly 1–3.5 cm. long..... 68

68. Blades pinnately veined, serrate; plants rather densely villous throughout, branches creeping, decumbent, or ascending.....
*Blephilia hirsuta* in swamp forests or other moist sites
*B. ciliata* in dry pioneer sites or Oak forests

68. Blades palmately veined or nearly so (3–5 main veins originating at or near the base of blade), usually deeply crenate..... 69

69. Plants with a pungent odor, stems creeping with many small ascending branches; blades orbicular or reniform..... *Glechoma hederacea*

69. Plants not with a pungent odor, stems merely decumbent (although sometimes rooting at the lower nodes) and branched mostly at the base..... 70

70. Lower leaf blades orbicular or broadly ovate, upper ones ovate, all petioled.... *Lamium purpureum*

70. All leaf blades orbicular or nearly so, the lower petioled, the upper sessile and more or less clasping..... *Lamium amplexicaule*

71. Leaves copiously black-dotted, especially at the margins; 4-ranked, glabrous, oblong or ovate-lanceolate, obtuse, sessile or short-petioled, mostly 1–2 cm. long..... *Hypericum punctatum*

71. Leaves not black-dotted..... 72

72. Leaves small, mostly 0.5–2 cm. long, crowded, thickish, entire, internodes very short, stem minutely more or less highly branched, stout and rigid..... 73

72. Plants not as above..... 75

73. Leaves all less than 1 cm. long, 1–3 mm. broad, spatulate, oblanceolate or obovate, sparingly short-pubescent above and sometimes appearing ciliolate but the hairs not in definite rows, petioles usually as long as or longer than the blades; highly branched forms forming polsters ..... *Houstonia caerulea*

73. Most of the leaves more than 1 cm. long, sparingly short-pubescent above or glabrous, ciliate or not, petioles usually not as long as the blades ..... 74

74. Leaves ciliate, *i.e.*, the hairs in definite rows, blades elliptic to suborbicular, petioles usually shorter than the blades but sometimes as long or longer ..... *Houstonia canadensis*

74. Leaves not ciliate, *i.e.*, with the hairs in definite rows, although frequently appearing so, commonly glabrous throughout, petioles rarely as long as the blades and usually much shorter ..... *Houstonia longifolia*

75. Plants minute, leaves less than 5 mm. long, thin, close together but not crowded, slightly downy-pubescent, stems swollen at the nodes, simple or branched .... *Arenaria serpyllifolia*

75. Leaves longer than 5 mm ..... 76

76. Plants semi-aquatic, in well-lighted seepage areas; blades bright green, broadly ovate, orbicular or almost reniform, crenate ..... *Chrysosplenium americanum*

76. Plants terrestrial ..... 77

77. Blades deeply pinnatifid, the lobes acute or acuminate at the apex, dentate or incised-dentate, leaves 3–25 cm. long, petioles commonly purple with a pair of dilated, foliaceous appendages at the base ..... *Polymnia canadensis*

77. Leaves not pinnatifid ..... 78

78. Leaves entire or undulate ..... 79

78. Leaves serrate, crenate, dentate, or obscurely toothed ..... 91

79. Blades broadly obovate to wedge-shaped, sessile, clasping, and crowded on the simple, erect stem, the stem 6–10 cm. high, leaves entire, dark green, thickish or coriaceous, 0.8–2.5 cm. long ..... *Obolaria virginica*

79. Leaves not as above ..... 80

80. Blades orbicular or broadly ovate, mostly less than 2 cm. long, with short, unmargined petioles, glabrous throughout ..... 81

80. Blades not orbicular or broadly ovate, or if so, not otherwise as above ..... 82

81. Leaves dark green, some or all of them with a whitish midvein; plants characteristic of Hemlock, Hemlock-Beech, and Oak-Chestnut forests ..... *Mitchella repens*

81. Leaves bright green, not with a whitish midvein, minutely glandular-punctate, stem angled; common in swamp forests ..... *Lysimachia nummularia*

82. Blades linear or linear-lanceolate, glabrous throughout ..... 83

82. Blades not linear or linear-lanceolate, or if so, pubescent ..... 84

83. Leaves 2, 5–15 cm. long ..... *Claytonia virginica*

83. Leaves more than 2, 0.5–2.5 cm. long ..... *Stellaria longifolia*

84. Blades ovate or elliptic, mostly more than 2 cm. long, firm and somewhat coriaceous, usually dark green ..... 85

84. Blades obovate, oblanceolate, or if ovate, then less than 2 cm. long, not at all coriaceous, usually bright green ..... 87

85. Stems prostrate and trailing, plants forming a dense carpet over the ground, stems usually much longer than 15 cm.; leaves glabrous, short-petioled, glossy .... *Vinca minor*

85. Stems erect or ascending, or rarely decumbent, not trailing, usually less than 15 cm. long, plants occurring singly; margins of blades rough with short, stiff hairs ..... 86

86. Leaves sessile, 1-veined ..... *Phlox divaricata*

86. Blades narrowed into short, margined petioles, lateral veins conspicuous and uniting near the margin ..... *Phlox paniculata*

87. Plants glabrous except for a line of hairs along the petioles and stem; blades ovate, frequently cordate at the base ..... *Stellaria media*

87. Plants more or less pubescent throughout ..... 88

88. Leaves obovate, varying from 2–8 cm. long on the same branch, 1–3 cm. broad, softly pubescent above, smooth and satin-like beneath; Jackson, Hocking, Fairfield, and Athens Counties ..... *Phlox stolonifera*
88. Leaves oblanceolate, spatulate or spatulate-oblong, the largest not over 4 cm. long and rarely more than 1 cm. broad ..... 89

89. Leaves mostly 2–4 cm. long, oblanceolate or spatulate, sparingly hirsute above, glabrous or nearly so beneath, thin; petioles margined, rather slender, usually as long as or longer than the blades ..... *Cerastium nutans*
89. Leaves mostly 1–2 cm. long, obovate or spatulate, or the blades oblong, hirsute above and below, thick ..... 90
90. Leaves mostly 1–2 cm. long and 0.5–1 cm. broad on short stems; chiefly southern and eastern Ohio ..... *Cerastium viscosum*
90. Leaves mostly less than 1 cm. long and 0.5 cm. broad, on ascending or decumbent stems with elongated internodes; common weed of moist sites .... ..... *Cerastium vulgatum*

91. Blades finely and regularly serrate, 1–3 cm. long, softly pubescent throughout ..... ..... *Veronica officinalis*
91. Blades not finely serrate as above ..... 92
92. Blades denticulate; oblong, thick and fleshy, 0.5–2 cm. long, glabrous ..... ..... *Veronica peregrina*
92. Blades crenate, crenulate, dentate (sometimes entire in *V. serpyllifolia*) ..... 93

93. Blades crenulate or rarely entire, mostly 0.5–1 cm. long, glabrous or puberulent ..... ..... *Veronica serpyllifolia*
93. Blades pubescent; crenate, dentate, or crenulate ..... 94
94. Blades crenate to dentate, 0.5–2 cm. long, ovate or oval, more or less pubescent; not common ..... *Veronica persica*
94. Blades crenate or crenulate, broadly ovate to oval, 5–12 mm. long; common weed ..... *Veronica arvensis*

95. Leaves with milky sap ..... 96
95. Leaves not with milky sap ..... 104
96. Teeth minutely but conspicuously white callose-tipped, the margins more or less strongly crisped; leaves less than 8 cm. long, in flat rosettes ..... 97
96. Margins not both crisped and with callose-tipped teeth ..... 100

97. Plants of swamp forests, stream banks and open, marshy places ..... 98
97. Plants of dry woods or fields, or waste grounds ..... 99
98. Leaves acute at the apex, smooth and glabrous throughout or sparingly short-pubescent; along stream banks or sometimes in open, marshy places ..... ..... *Lobelia cardinalis*
98. Leaves obtuse at the apex or sometimes acutish, short-pubescent or glabrate above, glabrous beneath; swamp forest species, less frequently in open wet places ..... *Lobelia siphilitica*

99. Leaves loosely hirsute above, and especially on the veins beneath, thin; dry woods, fields and waste grounds; biennial ..... *Lobelia inflata*
99. Leaves pubescent on both sides with short, stiff hairs, especially near the base and margins, thickish and firm; dry, mostly sandy soil; perennial ..... *Lobelia spicata*
100. Margins remotely denticulate, none of the leaves lobed or pinnatifid; leaves usually much less than 10 cm. long, 1–3 cm. broad, obovate to oblanceolate, if pubescent, with erect hairs about 1 cm. long ..... 101
100. At least some of the leaves lobed or pinnatifid, or if not, then not otherwise as above ..... 102

101. Leaves glabrous, or nearly so, more or less purple-veined ..... *Hieracium venosum*
101. Leaves, at least the younger ones, villous-hirsute, not purple-veined ... *Hieracium gronovii* *H. paniculatum*
102. Leaves prickly on the margins and veins beneath ..... *Lactuca scariola*
102. Leaves not prickly as above ..... 103

103. Petioles and leaf rachises not hollow..... *Lactuca* spp.
103. Petioles and leaf rachises hollow..... *Taraxacum officinale*
104. Leaves prickly, large..... 105
104. Leaves not prickly..... 106
105. Leaves glabrous; blades very rugose, with whitish, stout, blunt spines on the veins, especially the midvein beneath, and scattered on the upper surface, crenate, dark green..... *Dipsacus sylvestris*
105. Leaves more or less strigose-pubescent or hispid above and below; margins and sometimes the veins beneath with sharp spines, usually more or less triangular-lanceolate lobed or pinnatifid, or sometimes merely serrate, dark or bright green..... *Cirsium* spp.
106. Most of the leaves with pinnatifid, lobed, or incised blades..... 107
106. Most of the leaves not with pinnatifid, lobed or incised blades..... 133
107. Most of the blades pinnately lobed, incised, or pinnatifid (excluding all that are only 2- or 3-lobed)..... 108
107. Most of the blades palmately lobed (including all that are 2- or 3-lobed) or incised..... 125
108. Blades suborbicular or broadly ovate in outline, broadest across the lowest pair of segments or lobes, the segments or lobes shallow or deep, coarsely toothed or incised, petioles expanded at the base and clasping, the blades with or without large irregular patches of pale green or white on the upper surface, 3–7 lobed or divided..... 109
108. Blades not suborbicular or broadly ovate in outline, not broadest at base, nor splotched with pale green or white..... 111
109. Blades 3–7-divided, the terminal segment 3-lobed, glabrous or nearly so throughout, not splotched with pale green or white..... *Rudbeckia laciniata*
109. Blades 5–7-lobed, the lobes shallow or deep, more or less rough-pubescent throughout, usually splotched with pale green or white..... 110
110. Perennial, with large scaly rhizomes usually at or near the surface of the ground..... *Hydrophyllum canadense*
110. Biennial, without scaly rhizomes..... *Hydrophyllum appendiculatum*
111. Roots, petioles, and veins with bright orange or yellow sap; segments mostly 7, obovate or ovate, 2–3.5 cm. long, 1–2.5 cm. broad, crenate-lobed, the lobes or teeth all very obtuse, petioles dilated at the base and clasping..... *Chelidonium majus*
111. Plants not with bright orange or yellow sap, or if so, not otherwise as above..... 112
112. Leaves with stellate-pubescence; more or less lobed or pinnatifid, 3–15 cm. long, the lobes acute and toothed..... *Capsella bursa-pastoris*
112. Leaves not with stellate pubescence..... 113
113. Leaves granular-viscid on the lower side; spatulate-oblong in outline, pinnatifid or lyrately lobed, 4–10 cm. long, about 1 cm. broad, hoary-pubescent with white scale-like hairs, often in pairs..... *Lepidium campestre*
113. Leaves not granular-viscid on the lower side, or not otherwise as above..... 114
114. Blades runcinate-pinnatifid..... 115
114. Blades not runcinate-pinnatifid..... 116
115. Leaves pubescent with rather long, scattered, stiff hairs; lobes 3–6 pairs and the terminal, dentate, crenate, lobed or entire..... *Sisymbrium officinale*
115. Leaves glabrous, or if pubescent, with soft, downy hairs; lobes wavy-toothed or entire, often auriculate at the base, usually 6 or more pairs and the terminal one..... *Sisymbrium altissimum*
116. Blades deeply pinnatifid, *i.e.*, divided to, or almost to the midvein, the midvein unmargined or slightly margined, the lateral segments distinct or almost distinct and rather uniform in size..... 117
116. Blades not deeply pinnatifid as above..... 123
117. Plants strictly aquatic, usually in small streams or at outlets of springs, many plants occurring together and covering the water surface; leaves not in rosettes (except in late winter), 3–9 segments, terminal one larger than the lateral and nearly orbicular, about 1 cm. broad..... *Nasturtium officinale*

117. Plants terrestrial, or if in aquatic habitat, the leaves in distinct, usually symmetrical rosettes ..... 118
118. Terminal lobe orbicular or suborbicular, 2–5 cm. broad, the lateral segments distinct, or nearly so, all entire or undulate ..... 119
118. Terminal lobe not orbicular, or if so, not otherwise as above ..... 120
119. 1–4 pairs of lateral segments ..... *Barbarea vulgaris*
119. 4–8 pairs of lateral segments ..... *Barbarea verna*
120. Terminal lobe greatly exceeding the lateral ones in size ..... 121
120. Terminal lobe not greatly exceeding the lateral ones in size although it may be distinctly larger, narrowed at the base, 2–8 pairs of lateral segments; sometimes submerged ..... *Cardamine pensylvanica*
121. Leaves pubescent with scattered stiff hairs; 2–4 lateral segments ..... *Brassica nigra*
121. Leaves glabrous or puberulent ..... 122
122. Blades spatulate in outline, numerous very small lateral segments, glabrous or puberulent; common weed of fields, gardens, and waste grounds ..... *Lepidium virginicum*
122. Blades oblong or oblanceolate in outline, 6–8 small lateral segments, smooth and glabrous; bases of petioles dilated and clasping; chiefly in moist or wet places, or shallow water ..... *Rorippa islandica*
123. Blades hirsute or pubescent, dotted with minute glands; obovate or broadly oblong in outline, lyrate-pinnatifid, the lobes usually shallow or deeper toward the base, undulate-dentate ..... *Salvia lyrata*
123. Blades glabrous or nearly so ..... 124
124. Petioles usually as long as or longer than the blades; blades spatulate or oblanceolate in outline, rarely over 2 cm. broad, irregularly pinnatifid or subpinnatifid and the lobes very irregularly dentate, not rugose, the margins more or less strongly but loosely crisped ..... *Chrysanthemum leucanthemum*
124. Blades sessile or very short-petioled; oblong to lanceolate in outline, usually more than 2 cm. broad, more or less deeply lobed or pinnatifid, the lobes with sinuate-crenate to dentate margins, conspicuously rugose above ..... *Verbascum blattaria*
125. Stipules in the form of ochreae; blade hastate, the basal lobes spreading; blades 2–7 cm. long, glabrous and entire, or the basal lobes 1–2-toothed ..... *Rumex acetosella*
125. Stipules, if present, not in the form of ochreae ..... 126
126. Blades shallowly 3–9-lobed, small stipules adnate to the bases of the petioles, the tips free ..... 127
126. Blades more or less deeply 3- or 5-lobed, without stipules or with large membranous stipules, the tips not free ..... 129
127. Petioles glabrous or puberulent, blades 7–9-lobed, the lobes rounded at the apex ..... *Heuchera americana*
127. Petioles retrorsely hirsute, blades 3–5-lobed, the lobes acute or acuminate at the apex ..... 128
128. Stipules with deeply fimbriate tips ..... *Tiarella cordifolia*
128. Stipules merely glandular-ciliate or slightly and shallowly fimbriate ..... *Mitella diphylla*
129. Lobes with entire margins; blades reniform or broadly ovate in outline; usually broader than long, thickish and firm, 4–12 cm. broad, 3-lobed, the lobes ovate ..... 130
129. Lobes serrate, dentate, crenate, or incised ..... 131
130. Lobes acute at the apex ..... *Hepatica acutiloba*
130. Lobes obtuse or rounded at the apex ..... *Hepatica americana*
131. Blades and petioles smooth and glabrous, or nearly so, blades 3–5-lobed, the lobes obtusely cut and toothed; swamps, ponds, and wet ditches ..... *Ranunculus sceleratus*
131. Blades and petioles more or less pubescent, or if glabrous, then not otherwise as above ..... 132
132. Blades broadly reniform, broader than long, 3-lobed, the lobes usually acute and toothed, densely hirsute throughout, or rarely glabrate; woodland species ..... *Ranunculus recurvatus*

132. Blades palmately 3–5-lobed, orbicular or broadly ovate in outline, the lobes acute or acuminate at the apex, coarsely and sharply dentate and incised, very veiny, more or less finely rough-pubescent; roadsides, fields, and waste grounds ..... *Leonurus cardiaca*
133. At least some of the blades distinctly cordate at the base ..... 134
133. None of the blades distinctly cordate at the base ..... 150
134. Leaves with membraneous, sheathing, united stipules (ochreae) ..... 135
134. Leaves without stipules, or if present, not in the form of ochreae ..... 136
135. Margins crisped, blades dark green, more or less papillose ..... *Rumex crispus*
135. Margins not crisped, merely undulate, blades bright green, petioles and veins usually red or reddish ..... *Rumex obtusifolius*
136. Blades with entire, undulate or angled margins ..... 137
136. Blades serrate, dentate, crenate, or crenulate ..... 139
137. Plants aquatic; blades yellow-green, deeply cordate, with a conspicuous crimson spot at the base of the midvein ..... *Nuphar advena*
137. Plants terrestrial ..... 138
138. Blades angled, the angles obtuse or acutish; blades orbicular or broadly oblong, 1–2.5 cm long, dark green, firm and leathery, glabrous throughout ..... *Cardamine bulbosa*
*C. douglassii*
138. Blades entire or undulate; ovate or oval, 2–5 cm. long, prominently pinnately-veined, obtuse and rounded at the apex or acute, smooth and glabrous except for the long-ciliate petioles and ciliate margins, especially on the younger leaves ..... *Lysimachia ciliata*
139. Blades deltoid-ovate or oblong in outline with flaring teeth at the base, sparingly and shallowly serrate above, 3–5 cm. long, obtuse or acute at the apex ..... *Viola sagittata*
139. Blades not as above ..... 140
140. Most of the leaves obtuse to very obtuse and rounded at the apex ..... 141
140. Most of the leaves acute or sometimes acuminate at the apex ..... 144
141. Blades rugose, especially above, dark green above, lighter beneath and often purplish; serrate-crenate, ovate or orbicular ..... *Senecio aureus*
141. Blades not rugose above, bright green ..... 142
142. Sinuses at the base of the blade wide and shallow; crenate, sometimes 2–3-lobed ..... *Ranunculus abortivus*
142. Sinuses not broad, sometimes wanting ..... 143
143. Blades crenate or crenate-dentate, some of them sometimes 3-divided ..... *Thaspium trifoliatum*
143. Blades sharply serrate, some of them sometimes ternately decompound ..... *Zizia aurea*
144. Blades mostly less than 2.5 cm. long, broadly ovate to orbicular, regularly and often rather finely crenate-serrate ..... 145
144. Blades mostly 3–7 cm. long, broadly ovate to almost lanceolate, coarsely and frequently irregularly serrate or dentate ..... 147
145. Teeth conspicuously yellowish callose-tipped; sparingly pubescent with short, flat, ribbon-like hairs ..... *Campanula americana*
145. Teeth not yellowish callose-tipped ..... 146
146. Leaf tufts arising directly from the rhizome ..... *Viola papilionacea*
*V. triloba*
*V. blanda*
146. Leaf tufts arising from the ends of short or dwarfed stems, several stems from each rhizome, blades rarely over 2 cm. broad, with small stipules ..... *Viola striata*
*V. rostrata*
*V. conspersa*
147. Leaves densely velvety-pubescent above and below; blades ovate to broadly ovate, irregularly shallowly dentate-crenate or crenulate ..... *Aster undulatus*
147. Leaves not densely pubescent as above ..... 148

148. Blades large, 10–15 cm. long, 5–13 cm. broad, with broad, sharp-pointed teeth, sinuses deep and irregular, rough-pubescent above with scattered hairs; frequently in colonies ..... *Aster macrophyllus*
148. Blades 3–8 cm. long ..... 149

149. Blades sharply dentate, the teeth with conspicuous incurved, bristle-like tips 0.5–1 mm. long; chiefly in the Plateau ..... *Aster divaricatus*
149. Blades serrate, or sometimes the teeth blunt, sometimes with bristle-like tips but always minute (tips less than 0.5 mm. long), usually purple beneath, petioles ciliate at least toward the base; common in woods throughout the State ..... *Aster cordifolius*
150. Leaves densely woolly with long, branched hairs above and below, or white-tomentose, especially below; not 3-veined ..... 151
150. Leaves not densely woolly or white-tomentose as above, or if white-tomentose below, then 3-veined ..... 152

151. Leaves woolly with long, coarse, branched and interlacing hairs, mostly 5–15 cm. long ..... *Verbascum thapsus*
151. Leaves softly white-tomentose, especially densely so below, 2–5 cm. long ..... *Gnaphalium* spp.
152. Leaves with stellate or 2-branched hairs, although some of the hairs may be simple ..... 153
152. Pubescence when present of simple hairs ..... 155

153. Leaves mostly 2–4 cm. long ..... 154
153. Leaves mostly 0.5–1.5 cm. long; entire or dentate near the apex, more or less pubescent on the upper surface with simple, 2-branched and stellate hairs; chiefly in the southern counties ..... *Draba verna*
154. Pubescence of stellate and 2-branched hairs, not appressed, blades narrowed into slender petioles about the same length as the blades, entire or sparingly shallow-toothed; old sandy fields and pastures ..... *Arabidopsis thaliana*
154. Pubescence of 2-branched and simple, appressed hairs, blades narrowed into short petioles, coarsely toothed or repand-denticulate; cultivated and waste grounds ..... *Erysimum repandum*

155. Blades prominently 3- or 5-veined ..... 156
155. Blades not prominently 3- or 5-veined ..... 165
156. Leaves linear, grass-like, 3–15 cm. long, 2–6 mm. broad, acuminate at the apex, 3-veined ..... *Plantago aristata*
156. Leaves not linear, or if so, not many times longer than broad ..... 157

157. Leaves dull dark green and arachnoid above, densely white-tomentose beneath, 3-veined, obovate, spatulate or broadly oval, often forming broad patches ..... *Antennaria plantaginifolia*
157. Leaves not white-tomentose beneath ..... 158
158. Blades entire or sometimes repand-denticulate ..... 159
158. Blades sharply serrate or dentate, the teeth usually shallow ..... 162

159. Leaves villous-pubescent ..... 160
159. Leaves glabrous or short-pubescent ..... 161
160. Leaves densely villous-pubescent, oblong, obovate or sometimes linear, acute or obtusish at the apex, entire; prairie species rare except locally ..... *Castilleja coccinea*
160. Leaves villous-pubescent, but not densely so, grayish-green, obovate or spatulate, obtuse or acutish at the apex, entire or repand-denticulate; moist pioneer sites and open swamp forests of the southern and southeastern Plateau ..... *Plantago virginica*

161. Leaves glabrous, not over 2.5 cm. long, broadly ovate to orbicular, sessile or nearly so, pale green, in a 4–8-leaved rosette, the leaves paired with regard to size ..... *Sabatia angularis*

161. Leaves short-pubescent with a tuft of brownish or whitish hairs at the base of the margined petioles, 4–15 cm. long, narrowly oblong-lanceolate or linear- elliptic, dark green ..... *Plantago lanceolata*

162. Blades sharply serrate, the teeth rather shallow and not remote, tapering gradually into short, margined petioles, smooth and glabrous except for the rough-ciliolate margins and the ciliate petioles, internodes slightly elongated.. ..... *Solidago gigantea*

162. Blades serrate or dentate, but sparingly so, more or less abruptly narrowed into margined petioles, mostly bristly-hispid, leaves distinctly tufted and usually spreading on the ground ..... 163

163. Leaves thin, bright green, rather softly pubescent above and below, usually some of them 3-lobed or 3-divided ..... *Rudbeckia triloba*

163. Leaves thick, more or less hirsute or hispid, never 3-lobed or 3-divided ..... 164

164. Leaves dark green, blades of at least some of them abruptly narrowed into distinctly margined petioles, the margins 0.8–3 mm. broad; confined to the prairies ..... *Rudbeckia speciosa*

164. Leaves bright green, blades narrowed into very slightly margined petioles; prairie species, but also in fields, along roadsides, and in waste grounds..... ..... *Rudbeckia hirta*

165. Blades entire, undulate, denticulate, crenulate or serrulate (*i.e.*, entire or obscurely toothed) ..... 166

165. Blades distinctly serrate, dentate, or crenate ..... 186

166. Petioles with stipules in the form of ochreae; leaves large, glabrous ..... 167

166. Stipules, if present, not in the form of ochreae ..... 168

167. Margins crisped, blades dark green; more or less papillose ..... *Rumex crispus*

167. Margins not crisped, merely undulate; petioles and veins usually red or reddish, blades bright green ..... *Rumex obtusifolius*

168. Blades granular-viscid on the lower side, hoary-pubescent with scale-like hairs, often in pairs, entire, obtuse at the apex, blades tapering to petioles..... ..... *Lepidium campestre*

168. Blades not granular-viscid on the lower side ..... 169

169. Blades conspicuously glandular-dotted; ovate, 1–5 cm. long, crenate with shallow teeth, undulate or entire, obtuse or acutish at the apex, abruptly narrowed at the base and usually subcordate, sparingly pubescent throughout; common in waste grounds and disturbed forests ..... *Prunella vulgaris*

169. Blades not glandular-dotted ..... 170

170. Blades entire ..... 176

170. Blades undulate, denticulate, serrulate or crenulate, sometimes minutely so... 171

171. Blades crenulate or plicate-crenulate; oval, elliptic or orbicular, reticulately veined, smooth and glabrous, petioles unmargined; Hemlock-Hardwood forests ..... 172

171. Blades not crenulate or plicate-crenulate, petioles margined when present ..... 173

172. Blades plicate-crenulate, broadly oval or elliptic, thin, membranous, dull dark green, usually mucronulate at the apex, longer than the petioles..... ..... *Pyrola elliptica*

172. Blades crenulate, orbicular or oval, coriaceous, bright green and shining above, usually as short as the petioles ..... *Pyrola rotundifolia*

173. Leaves smooth and glabrous, margins closely, irregularly, and sharply serrulate and curled under, blades usually strongly but loosely rugose, oblong, 2–7 cm. long, 0.5–2 cm. broad, bright green; wet pioneer habitats ..... *Epilobium coloratum*

173. Leaves not glabrous, or if so, not otherwise as above ..... 174

174. Petioles mostly much shorter than the blades ..... 175

174. Petioles mostly as long as or longer than the blades, slender and slightly margined, leaves 8–30 cm. long, 2–4.5 cm. broad, blades ovate-lanceolate or oblong, serrulate or rarely entire, more or less scabrous above with short hairs; uncommon except locally in prairie areas ..... *Solidago rigida*

175. Blades irregularly undulate-denticulate, the narrowed portion at the base frequently dentate, acute or acuminate at the apex, pinnately-veined, the midvein broad and the lateral prominent, lanceolate or oblong-lanceolate; common in old fields, along roadsides and streams, and in waste grounds ..... *Oenothera biennis*
*Gaura biennis*

175. Blades regularly and minutely denticulate, obtuse or acutish at the apex, 1-veined, oval, ovate, obovate, or oblanceolate, thick and leathery; uncommon except locally in wet or moist grounds ..... *Saxifraga pensylvanica*

176. Largest leaves mostly less than 1 cm. broad; linear, oblong, oblanceolate, or if less than 5 cm. long, sometimes spatulate ..... 177

176. Largest leaves mostly more than 1 cm. broad; oblanceolate, obovate or spatulate ..... 182

177. Leaves densely silky-pubescent with long spreading hairs, narrowly oblanceolate; weed, especially of grainfields ..... *Agrostemma githago*

177. Leaves not densely silky-pubescent as above ..... 178

178. Leaves hoary-pubescent; roots reddish ..... 179

178. Leaves not hoary-pubescent ..... 180

179. Leaves obscurely veined, bright green ..... *Lithospermum arvense*

179. Leaves distinctly 1-veined, pale green ..... *Lappula echinata*

180. Leaves linear or narrowly linear-oblanceolate, 2–8 cm. long, 3–6mm. broad, dark green, rather thick and succulent, rigid, margins ciliate, otherwise glabrous or glabrate; chiefly in the Plateau, especially in upland *Andropogon* communities and in clearings ..... *Dianthus armeria*

180. Leaves spatulate, oblanceolate or oblong, usually less than 5 cm. long ..... 181

181. Plants stoloniferous, leaves tufted and ascending, oblong or oblanceolate, 2–5 cm. long, blades narrowed into broadly margined petioles, appressed short-pubescent; shallow pools, sluggish streams or other wet grounds ..... *Myosotis scorpioides*

181. Plants not stoloniferous, leaves in a flat rosette, oblanceolate or spatulate, 1–2 cm. long, blades narrowed into slender margined petioles, puberulent or glabrate, mucronate, margins more or less ciliate; old fields and open woods, especially in sandy soils ..... *Silene antirrhina*

182. Plants of rocky ledges, crevices, and cliff bases, Hocking, Jackson, Pike, and Ross Counties; leaves obovate or broadly spatulate, mostly 2–4 cm. long, obtuse at the apex but pointed, margins more or less crisped ... *Silene rotundifolia*

182. Plants not as above ..... 183

183. Leaves tufted, ascending, thin and tender, smooth and glabrous except for occasional hairs on the margins, upper surface and the midvein beneath, spatulate to obovate, obtuse and rounded at the apex, mucronate, 5–10 cm. long, 1–2 cm. broad, petioles margined, much longer than the blades; common in moist pioneer habitats ..... *Valerianella intermedia*

183. Leaves spreading on the ground, or if ascending, not otherwise as above ..... 184

184. Petioles as long as or longer than the blades, margined, slender, leaves glabrate, thick and firm, dark green; 2–25 cm. long, spatulate or oblanceolate, 1-veined; Oak-Chestnut woods or forest borders ..... *Silene virginica*

184. Petioles much shorter than the blades, broadly margined, bright green, not thick and firm, softly pubescent throughout; pioneer habitats ..... 185

185. Blades pinnately veined, the veins prominent and commonly lighter green or yellowish ..... *Lychnis alba*

185. Blades 1-veined, the lateral veins not prominent ..... *Silene noctiflora*

186. Blades deltoid-ovate or oblong in outline with flaring teeth or incised-dentate at the base, sparingly and shallowly serrate above, petioles unmargined, slender ..... *Viola sagittata*

186. Blades not as above ..... 187

187. Margins strongly and closely crisped, rest of blade flat or nearly so; obovate to oblanceolate ..... 188

187. Margins not strongly and closely crisped, or if so, rest of blades more or less rugose, or not otherwise as in 188 ..... 189
188. Blades thick, firm and somewhat succulent, light green and obscurely veined above, reddish beneath and 1-veined, short-pubescent or glabrate, mostly dentate, the abruptly narrowed basal portion entire, petioles broad, margined; dry or rock banks along forest borders, in the Plateau .... *Saxifraga virginiensis*
188. Blades thickish, dark green, 1-veined above, sparingly long-pubescent above, smooth and glabrous beneath, sharply serrate-dentate or almost laciniate; wooded slopes of ravines or stream banks ..... *Arabis laevigata*
189. Leaves more or less hispid-pubescent, the hairs not minute, mostly easily seen with the unaided eye ..... 190
189. Leaves glabrous, or with minute hairs on the upper surface, or the margins sometimes ciliate ..... 194
190. Blades mostly abruptly narrowed into slender, slightly margined petioles usually longer than the blades ..... 191
190. Blades mostly cuneate at the base or gradually narrowed into relatively broad, margined petioles shorter than the blades ..... 192
191. Blades coarsely and usually deeply dentate, sometimes incised-dentate toward the base, pubescence spreading, 2.5–7 cm. broad ..... *Erigeron annuus*
191. Blades sparingly shallow-serrate or almost entire, pubescence somewhat appressed, 0.5–1.5 cm. broad ..... *Erigeron strigosus*
192. Petioles long-ciliate; leaves 2–10 cm. long, 1–2 cm. broad, sparingly coarsely dentate or incised-dentate, biennial; weed of fields, roadsides and waste ground ..... *Erigeron canadensis*
192. Petioles not long-ciliate, perennials; mostly forest or woodland border species .. 193
193. Blades thin, rather sparingly pubescent above and below, the hairs not long, coarsely or shallowly dentate; swamp forests or moist pioneer habitats ..... *Erigeron philadelphicus*
193. Blades thickish and firm, long-pubescent above and below, the hairs stiff or stiffish, especially dense along the margins, sparingly and remotely shallow-toothed; woodland borders, rarely in pioneer habitats ..... *Erigeron pulchellus*
194. Leaves with a garlicky odor when crushed; oblanceolate, coarsely dentate, long-petioled, in a flat rosette, biennial; waste grounds ..... *Thlaspi arvense*
194. Leaves not with a garlicky odor when crushed, perennials ..... 195
195. Most of the blades sharply serrate all around, or the narrowed basal portion entire, the teeth not shallow, appressed or remote, blades very thin and flat, or curled as though not fully expanded, bright green, abruptly narrowed into slightly margined petioles, glabrate above, glabrous below, not scabrous; forest species, especially in Beech-Sugar Maple and Oak-Chestnut types ..... 196
195. Blades not mostly sharply serrate all around, thin, or abruptly narrowed into slightly margined petioles as above ..... 197
196. Leaves 1.5–5 cm. long, 1–2 cm. broad, usually curled as though not fully expanded, blades ovate to lanceolate ..... *Solidago caesia*
196. Leaves 5–15 cm. long, 2–5 cm. broad, flat, blades ovate to broadly elliptic, often doubly serrate ..... *Solidago flexicaulis*
197. At least the upper surface of the blades more or less scabrous (when rubbed toward the base) with minute, stiffish hairs, or minutely pubescent with more than occasional hairs and not scabrous ..... 198
197. Leaves entirely glabrous, or glabrous except for the ciliate or ciliolate (sometimes very minutely so) margins ..... 202
198. Leaves large, mostly 8–20 cm. long ..... 199
198. Leaves all usually much less than 8 cm. long ..... 200
199. Blades oval or elliptic, thickish and somewhat rugose, very rough above when rubbed toward the base, obtuse or acute at the apex; swamps, bogs, and seepage slopes ..... *Solidago patula*

199. Blades lanceolate or elliptic-lanceolate, rather thin and not rugose, acute or subacuminate at the apex, pubescent above with minute hairs but not scabrous; dry pioneer habitats ..... *Solidago juncea*
    200. Blades rugose above and below, petioles usually shorter than the blades; minutely pubescent or scabrous above, ciliolate, blades oval, ovate or lanceolate, thickish, sharply serrate ..... *Solidago rugosa*
    200. Blades not rugose, petioles usually longer than the blades ..... 201
201. Plants of dry pioneer habitats, especially in sandy or clayey soil; densely minutely pubescent or scabrous, blades mostly spatulate ..... *Solidago nemoralis*
201. Plants of swamp forests, stream banks and roadside ditches; pubescent, scabrous or glabrate, blades ovate or ovate-lanceolate ..... *Aster prenanthoides*
    202. Leaves thick and succulent, very smooth and flat, glaucous or light green, glabrous except for the ciliolate margins (sometimes minutely so), shallowly crenate or serrate ..... 203
    202. Leaves bright or dark green, usually thickish and sometimes slightly succulent, but usually not extremely smooth, never glaucous, with or without marginal hairs ..... 204
203. Leaves not glaucous, light green; Oak-Chestnut woods of the Plateau; margins conspicuously ciliolate, mostly crenate, blades obtuse to very obtuse and rounded at the apex, petioles shorter than the blades, broad and flat ..... *Solidago erecta*
203. Leaves usually conspicuously glaucous as well as light green; cliffs and wooded bluffs, or dry roadside banks, general distribution; margins with minute, rigid, forward-pointing hairs, irregularly serrate-crenate, petioles slightly to broadly margined, shorter or longer than the blades, blades acute or obtuse and rounded at the apex .... ..... *Aster laevis*
    204. Blades obovate with a cuneate base, suborbicular or broadly spatulate, more or less rugose, dark green, very obtuse and rounded at the apex, regularly crenate-dentate, often purple below, entirely glabrous or the very young ones silvery webbed-hairy, in a flat rosette ..... *Senecio obovatus*
    204. Blades not as above ..... 205
205. Blades ovate, abruptly narrowed into slightly margined petioles usually longer than the blades; swamp forests ..... *Aster lateriflorus*
*A. prenanthoides*
205. Blades not both ovate and abruptly narrowed into slightly margined petioles ..... 206
    206. Blades sharply serrate with flaring, acuminate teeth, chiefly from the middle to the apex, acute or acuminate at the apex, long-tapering at the base, minutely ciliolate; swamp forests ..... *Aster tradescanti*
    206. Blades not sharply serrate as above, shallow-serrate, denticulate or almost entire ..... 207
207. Leaves ciliate; spatulate or oblanceolate, 2–10 cm. long, 0.5–1.5 cm. broad, sparingly shallow-serrate above the middle or almost entire; dry or moist pioneer sites .. *Aster pilosus*
207. Leaves not ciliate; blades lanceolate or oblong-lanceolate, irregularly denticulate, 4–10 cm. long, 1–1.5 cm. broad; wet pioneer sites ..... *Aster puniceus*

## LITERATURE CITED

**Beatley, Janice C.** 1953. The primary forests of Vinton and Jackson Counties, Ohio. Ph.D. dissertation, Ohio State University. Columbus, Ohio.

**Braun, E. L.** 1928. The vegetation of the Mineral Springs region of Adams County, Ohio. Ohio Biol. Surv. Bull. 15.

**Dole, R. M.** 1927. Snow cover, cold waves and zero temperatures. Mo. Weath. Rev. 55: 82.

**Earl. Grace T.** 1907. Evergreen plants of Ohio. Ohio Nat. 7: 188–189.

**Fernald, M. L.** 1950. Gray's manual of botany, 8th ed. American Book Co. New York.

**Gleason, H. A.** 1952. The new Britton and Brown illustrated flora of the northeastern United States and adjacent Canada. 3 vols. The New York Botanical Garden. New York.

**Georgia, Ada E.** 1923. A manual of weeds. The MacMillan Co. New York.

**Griggs, R. F.** 1914. A botanical survey of the Sugar Grove region. Ohio Biol. Surv. Bull. 3.

**Hitchcock, A. S.** 1950. Manual of the grasses of the United States, 2nd ed. Rev. by Agnes Chase. U. S. D. A. Misc. Pub. 200. U. S. Govt. Printing Office. Washington, D. C.

**Lidforss, B.** 1907. Die Wintergrune flora. Lunds. Univers. Arsskr. N. F., 2, Avd. 2, No. 13. 76 pp.

**Muenscher, W. C.** 1935. Weeds. The MacMillan Co. New York.

**Nillson, A.** 1949. The winter hardiness of biennial and perennial ornamental herbs (translated title). Agric. Hort. Genet. 7: 29–79.

**Rosendahl, C. O.** 1914. Experiments in forcing native plants to blossom during winter months. Plant World 17: 354–361.

**Rosendahl, C. O., F. K. Butters,** and **Olga Lakela.** 1936. A monograph of the genus *Heuchera*. Minn. Stud. in Plant Sci. 2: 6–7, 53–54.

**Runnels, H. A.,** and **J. H. Schaffner.** 1931. Manual of Ohio weeds. Ohio Agric. Exp. Sta. Bull. 475.

**Wolfe, J. N.** 1944. The use of weather bureau data in ecological studies. Ohio Jour. Sci. 44: 1–12.

**Wolfe, J. N., R. T. Wareham,** and **H. T. Scofield.** 1949. Microclimates and macroclimate of Neotoma, a small valley in central Ohio. Ohio Biol. Surv. Bull. 41.